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The New Method of the PV Panels Fault Detection Using Impedance Spectroscopy

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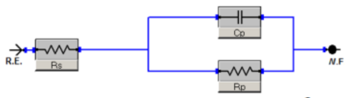
***Abstract*— The aim of our project is to develop a new method for photovoltaic (PV) panel fault detection based on analyzing impedance spectroscopy (IS) spectra. Although this technique was successful in assessing the state of degradation of fuel cells and batteries [1, 2], it has never been applied to PV cells on a wide scale. This step forward could be a turning point in PV fault identification as it provides a method that is easily implemented in the field and cheaper than the traditional techniques [3].**

***Keywords*— fault detection, impedance spectroscopy, silicon PV panels**

I. INTRODUCTION

The IS measurements provides a complex impedance value (Z_{PV}) for a range of AC signal frequencies. Using a fitting method on the measured data, it is possible to extract the parameters of the PV panel equivalent circuit [4] (see fig. 1). Analysis of the extracted parameters such as parallel capacitance C_p, parallel resistance R_p, and series resistance R_s, should allow us to rate the degradation state of PV module ́s individual parts [3,4].

II. FIGURES AND TABLES



$$Z_{PV} = \left[R_s + \frac{R_P}{(\omega R_P C_P)^2+1}\right] - j\left[\frac{\omega R_P{}^2 C_P}{(\omega R_P C_P)^2+1}\right]$$

Fig. 1. The complex impedance Z_{PV} equation of a PV panel (bottom) and its equivalent circuit model (top).

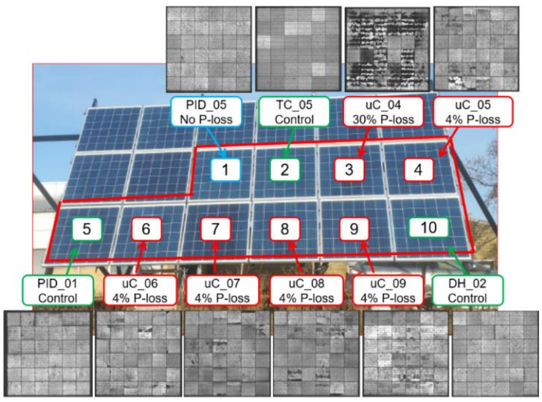


Fig. 2. The field station built at DTU Risø Campus for measuring current-voltage (IV) and IS spectra of PV panels along with weather conditions.

III. SUMMARY

We have built a field station at which IV, IS and weather conditions measurements are performed on 10 silicon solar panels (see fig. 2). Tests run from dawn until dusk and a fitting procedure is applied after a day of data collection. Six of the modules had been subjected to stress tests and exhibit power losses (P_{loss}) of 4% or 30% due to micro cracks. All the panels has been previously tested indoors by IS technique in dark conditions and by IV one in multi-irradiation conditions.

So far, the IS technique was only successful in the dark indoors conditions. We observe that the R_p values of control modules are 2,5x higher than the ones of modules with P_{loss}. Also, the module with 30% P_{loss} exhibits 2,5x higher R_s value than the rest of modules. These changes indicate a mechanical performance failure, which should be further investigated by IV measurements. Once G>100 W/m^2 the shapes of collected IS curves are the same for all degradation groups and, thus, extracted R_p, R_s, and C_p parameters do not differ either. This may be due to incorrect performance of our field test bed.

In the future we hope to be able to assess the P_{loss} value only through the field IS measurements. However, in order to achieve our goal, we first need to upgrade outdoor test bed and perform more indoor stress tests as a reference for the outdoor data.

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